Chapter 32 Protostome animals

BLY 122 Fall 2007 **Hilbun (from C. S. Major & Higgins)**

I. Why Do Biologists Study Protostomes?

A. Protostomes are the most abundant animals on Earth. (**Fig. 32.1**)
1. Protostomes are present in almost all habitats.
2. Protostomes are some of the most important model organisms in biology.

B. Crustaceans and Mollusks Are Dominant Animals in Marine Ecosystems
1. Crustacean and mollusk harvest is big business.
a. Shrimp, crabs, lobster, oysters, squid, and mussels are popular seafood delicacies.
b. Many are caught in the wild, so seafood companies consult biologists about the animals' life cycles, reproductive habits, and so on.
2. Crustaceans & mollusks - consumers, predators, & scavengers in marine food chains. (**Fig. 32.3**)

C. Insects, Spiders, and Mites Are Dominant Animals in Terrestrial Environments
1. Entomologists study insects in order to develop strategies for controlling their predation on human food supplies.
2. Insects & spiders important consumers, scavengers, & predators in terrestrial habitats. (**Fig. 32.4**)
a. Most angiosperms are pollinated by insects.
b. Insects and spiders are food for many predators higher in the food chain.

II. How Do Biologists Study Protostomes?

A. Research has drawn several general conclusions about the protostome lineage.
1. All protostome embryos experience similar embryonic development:
a. They have a spiral cleavage pattern.
b. They develop a mouth from the initial invagination during gastrulation.
c. If a coelom develops, it does so within blocks of mesoderm.
2. All protostomes are triplobastic bilaterally symmetrical with a head region that faces the environment.
3. Certain protostomes have segmented bodies.
4. The first fossil protostomes identified to date are 525–515 million years old.
5. Protostomes are a monophyletic group with two branching lineages—Lophotrochozoa and Ecdysozoa.

B. Biologists analyze morphology traits to understand the diversification of protostomes.
1. Changes in coelom formation.
a. Protostome ancestors were coelomate.
(1) Most modern protostomes have a tube-within-a-tube body design with a well-developed coelom. (**Fig. 32.5**)
(2) In these species the coelom forms a hydroskeleton that facilitates movement.
b. Platyhelminthes is an example of the reversion of some protostomes to the acoelomate body plan.
c. The pseudocoelom of some protostomes arose independently in rotifers and roundworms.
d. In Arthropoda and Mollusca, the coelom is drastically reduced, and they have a more complex body plan.
2. The appearance of an exoskeleton, segmentation, and jointed appendages
a. Arthropods
(1) Have an exoskeleton made of chitin and hardened by calcium carbonate (**Fig. 32.6a**)
(2) Move by contracting muscles that pull against the exoskeleton to move jointed appendages
(3) Have a fluid-filled hemocoel that holds internal organs and circulates body fluid
b. Mollusks
(1) Have a muscular foot used for movement, a visceral mass that contains the internal organs and an external gill, and the mantle that covers the visceral mass. (**Fig. 32.6b**)
(2) Are often protected by a calcium carbonate shell that is secreted by the mantle
(3) Move via a hydrostatic skeleton motion generated by the foot.
c. In both arthropods and mollusks, the exoskeleton provides protection from predation.

C. Using the Fossil Record
1. Other than the Bryozoa (**Fig. 32.7**) that appeared after the Cambrian explosion (515 mya), all other protostomes appear very early in animal evolution.
2. Two major events in protostome lineage are illustrated in the fossil record.
a. The extinction of the trilobites

(1) Trilobites are extremely abundant in the fossil record from 550 to 440 mya. (**Fig. 32.8a**)
(2) Trilobites were arthropods with an exoskeleton, segmented bodies, and jointed limbs.
(3) They lived on the sea floor and were mostly scavengers or deposit feeders.
(4) Trilobites disappear from the fossil record at 250 mya.

b. The appearance of insects
(1) Insects first appear in the fossil record at 400 mya.
(2) Winged insects appear in rocks that are up to 370 million years old. (**Fig. 32.8b**)
(3) This period corresponds with the Silurian-Devonian explosion of land plants, implying that the diversification of insects was preceded by that of land plants.

D. Evaluating Molecular Phylogenies
1. Molecular phylogenies using gene sequencing of the rRNA from the small ribosomal subunit demonstrated that protostomes are a monophyletic group that has two distinct lineages, Lophotrochozoans and Ecdysozoans.
2. It is not clear how these two groups diversified or how they are related, but recent results have provided initial data. (**Fig. 32.9**)

III. What Themes Occur in the Diversification of Protostomes?

A. Many different protostome groups moved to land independently—how?
1. They all evolved the ability to exchange gases on land by keeping a moist body surface exposed to air.
2. More important, they all evolved a way to prevent that gas exchange surface, and other body surfaces, from drying out.
a. Arthropods and mollusks have airtight exoseletons and gas exchange surfaces inside the body.
b. Insects can close their respiratory passages to keep them from drying out.

B. Protostome feeding strategies are diverse because they have a wide variety of specialized mouth parts.
1. Echiurans (spoon worms) are suspension feeders; they use a proboscis that forms a gutter leading to the mouth. (**Fig. 32.10a**)
2. Nemerteans (ribbon worms) are also suspension feeders; they use a proboscis that can extend and retract. (**Fig. 32.10b**)
3. Arthropod mouthparts vary from pinchers to tubes that allow them to feed off a variety of food sources. (**Fig. 32.10c, d, e**)
4. Many protostomes use their appendages to aid in feeding.
5. Metamorphosis in most protostomes results in larvae and adults that live in different areas and feed on different things, reducing intraspecific (within-species) competition.

C. Protostome variation in movement depends on two things:
1. The presence or absence of limbs
a. Protostomes that lack limbs move via a hydrostatic skeleton.
(1) This type of movement is seen in wormlike species.
(2) It is also observed in larvae (grubs, maggots, caterpillars, etc.).
b. The evolution of a variety of limbs introduced a variety of movements.
(1) The evolution of jointed limbs allowed for rapid, precise movement. (**Fig. 32.11a**)
(2) The evolution of the insect wing allowed flight. (**Fig. 32.11b**)
(3) In mollusks, waves of muscle contractions within the foot allow for gliding movements. (**Fig. 32.11c**)
(4) Water intake and forcible ejection through a siphon combine to move the squid via jet propulsion. (**Fig. 32.11d**)
2. The type of skeleton present
a. Hydrostatic skeletons allow movement in those animals without limbs.
b. Exoskeletons provide a point of insertion and resistance for appendage muscles.

D. Reproduction and Life Cycles
1. Asexual reproduction is common in protostomes.
a. Splitting the body lengthwise, or fragmentation, is common in many of the wormlike phyla.
b. Some crustaceans and insects reproduce asexually via parthenogenesis, when an unfertilized egg develops into an offspring.
2. Sexual reproduction is the predominant form of reproduction in most groups.
a. Begins with external fertilization in sessile forms such as clams, bryozoans, and brachiopods
b. Occurs with internal fertilization in crustaceans, snails, and insects
3. Two unique reproductive strategies evolved during protostome diversification.
a. Metamorphosis

(1) Allows juveniles to disperse to new habitats
(2) Reduces competition within species, because juveniles and adults often feed on different things

b. The evolution of an egg that won't dry out on land
(1) Insect eggs have a thick membrane that keeps moisture in.
(2) Snails and slugs have an egg with a thin calcium carbonate shell that retains water.

IV. Key Lineages of Lophotrochozoans

A. What do all lophotrochozoans have in common?
1. Lophophore (**Fig. 32.12a**)
a. A special structure that surrounds the mouth of suspension feeders
b. They have tentacles with ciliated cells along their surface.
c. The cilia beat, drawing food (that was trapped by the tentacles) into the mouth.
2. Trochophore (**Fig. 32.12b**)
a. A type of larva that has a ring of cilia around its middle.
b. The cilia aid in swimming and help sweep food toward the mouth.

B. Rotifera (Rotifers) (**Fig. 32.13**)
1. Feeding:
a. They do not have a lophophore, but they do have a cluster of cilia at their anterior end called a corona.
b. The beating of the cilia in the corona enables suspension feeding.
2. Movement: Most swim via cilia
3. Reproduction:
a. Asexual reproduction via parthogenesis
b. Sexual reproduction results in fertilized eggs that hatch into larvae, which develop directly into adults (no metamorphosis).

C. Platyhelminthes (Flatworms) (**Fig. 32.14**)
1. Feeding:
a. Lack a lophophore and have a "blind" digestive tract with only one opening
b. Most hunt protists, feed on dead animals, or are protists.
2. Movement:
a. Some turbellarians can swim; others can creep with the aid of cilia.
b. Cestodes and trematodes are largely sessile; many adult forms have hook-like structures that attach them to their hosts.
3. Reproduction:
a. Turbellarians reproduce asexually by splitting in half, or by fragmentation, but can reproduce sexually.
b. Trematodes and cestodes reproduce sexually by cross-fertilization and self-fertilization.
(1) Sexual reproduction occurs in a definitive host.
(2) Asexual reproduction occurs in one or more intermediate hosts.

D. Annelida (Segmented Worms) (**Fig. 32.15**)
1. Annelids are divided into two major groups.
a. Polychaeta have numerous bristle-like extensions called chaetae. (**Fig. 32.15a**)
(1) These chaetae extend from appendages called parapodia.
(2) Most polychaeta are marine animals, and many are burrowers.
b. Clitellata include oligochaetes and leeches. (**Fig. 32.15b**)
(1) Oligochaetes include earthworms and some other freshwater and marine species.
(2) Oligochaetes lack parapodia, and they have fewer chaetes than polychaetes do.
(3) Leeches are members of the Hirudinea and live in freshwater and marine habitats. (**Fig. 32.15c**)
2. Feeding:
a. Polychaetes have a wide variety of feeding methods.
(1) Burrowing polychaetes deposit feed.
(2) Sedentary forms feed via tentacles.
(3) Active forms hunt and capture small animals by everting their throats.
b. Most oligochaetes are deposit feeders that live in the soil.
c. Most leeches are ectoparasites that feed on the body fluids of their hosts.
3. Movement:
a. Polychaetes and oligochaetes crawl or burrow via a hydrostatic skeleton.
b. Some polychaetes swim via parapodia movement.

c. Leeches swim via undulating movements facilitated by the hydrostatic skeleton.

4. Reproduction:
   a. Polychaetes and oligochaetes reproduce asexually via transverse fission or fragmentation.
   b. Sexual reproduction in polychaetes involves separate sexes with eggs released into the water.
   c. Sexual reproduction in oligochaetes and leeches involves hermaphroditic individuals that cross-fertilize and generate mucus-rich eggs.

E. Mollusca (Mollusks)

1. Bivalves (Clams, Mussels, Scallops, Oysters) (**Fig. 32.16**)
   a. Feeding:
      (1) Bivalves have two shells that protect the visceral mass, foot, and mantle.
      (2) They are suspension feeders that feed when water is brought across gills, and food particles are trapped.
   b. Movement:
      (1) Clams burrow with their foot, but then are sessile.
      (2) Bivalves produce a swimming trochophore larva that can disperse to new locations.
      (3) Scallops can swim by clapping their shells together, forcing water to jet out and pushing them backward.
   c. Reproduction:
      (1) Only sexual reproduction occurs, and produces trochophore larva that hatch from eggs.
      (2) Trochophores metamorphose into larva called a veliger.
      (3) Veligers then metamorphose into adults.
2. Gastropoda (Snails, Slugs, Nudibranchs) (**Fig. 32.17**)
   a. Feeding:
      (1) Have a structure in their mouths called a radula that is used to scrape algae, plant cells, etc.
      (2) The radula is usually covered with teeth made of chitin.
      (3) Most gastropods are herbivores or detrivores, although some are predators.
   b. Movement: Glide via wavelike foot contractions.
   c. Reproduction:
      (1) Some females can reproduce asexually via parthenogenesis.
      (2) Sexual reproduction involves internal fertilization.
      (3) Some bivalves produce trochophore larva, then disperse after hatching; other species stay within the egg during metamorphosis and hatch as mini-adults.
3. Polyplacophora (Chitons) (**Fig. 32.18**)
   a. Feeding: Chitins have radula and scrape algae off of rocks.
   b. Movement: Move by gliding on their muscular foot
   c. Reproduction:
      (1) Fertilization is external, although some sperm shed into the water enter the female's body to fertilize eggs.
      (2) Sexes are separate.
      (3) Some eggs have a membrane and are released; others are retained and a live larva is born.
      (4) Most species have trochophore and veliger larvae.
4. Cephalopoda (Squid, Nautilus, Octopuses) (**Fig. 32.19**)
   a. Feeding:
      (1) They have heads with brains and eyes that enable intelligent hunting of fish or crustaceans.
      (2) They have a radula and a beak for biting.
      (3) Squid can inject poison into their prey.
   b. Movement:
      (1) Squid swim by undulating their bodies, or move via jet propulsion.
      (2) Octopuses crawl using tentacles.
   c. Reproduction:
      (1) They have separate sexes with courtship rituals.
      (2) Male deposit sperm in packets called spermatophores.
      (3) Females lay eggs that hatch and develop directly into adults.

V. Key Lineages of Ecdysozoans

A. What do all ecdysozoa have in common?

1. Ecdysozoans grow by molting—shedding their soft cuticle or hard exoskeletons—then they secrete a new one to fit the bigger body. (**Fig. 32.20**)
2. DNA sequence data shows that this is a monophyletic group with eight phyla. (**Table 31.1**)

B. Nematoda (Roundworms) (**Fig. 32.22**)
   1. Nematodes are unsegmented worms with a pseudocoelom.
      a. They have longitudinal muscles that lengthen and shorten during movement.
      b. Nematodes are common parasites in humans.
   2. Feeding:
      a. They eat bacteria, fungi, plant roots, protists and small animals.
      b. Mouthparts are specialized for what each species eats.
   3. Movement:
      a. Nematodes move via a hydrostatic skeleton.
      b. Muscle contraction causes wriggling that pushes against the stiff substrate of their environment.
   4. Reproduction:
      a. Sexes are separate, and fertilization is internal.
      b. Eggs are laid and hatch into offspring that develop directly into adults through a series of molts.

C. Arthropoda
   1. What do all arthropods have in common?
      a. Segmented bodies with a reduced coelom and a cavity filled with hemocoel
      b. A body with a well-defined head and trunk that is sometimes divided into an abdomen, thorax, and tail
      c. Paired, segmented appendages that function in gas exchange, feeding, and movement
      d. Compound eyes with many light-sensing structures, and a pair of antennae used for touch and smell
   2. Myriapods (Millipedes and Centipedes) (**Fig. 32.23**)
      a. Feeding:
         (1) They have mouthparts that can bite or chew.
         (2) Millipedes live in rotting plant materials and are detrivores.
         (3) Centipedes hunt insects using poison-containing fangs.
      b. Movement: Walk or run on their many legs
      c. Reproduction:
         (1) Sexes are separate, and fertilization is internal.
         (2) Males deposit or transfer sperm packets that are picked up by the females.
         (3) Females lay eggs that develop into juveniles, which molt several times while maturing into adults.
   3. Chelicerae (Spiders, Ticks, Mites, Horseshoe Crabs, Daddy longlegs, Scorpions)
      a. Feeding:
         (1) Capture prey with chelicerae, appendages near the mouth.
         (2) Most are sit-and-wait predators that build sticky webs to trap prey. **Fig. 32.24a**)
         (3) Mites and ticks are ectoparasites that feed on body fluids of animals. **Fig. 32.24b**)
         (4) Most scorpions feed on insects.
      b. Movement:
         (1) Move via paired antagonistic muscles attached to the exoskeleton.
         (2) Muscles move jointed legs that are used for walking, jumping, or swimming.
      c. Reproduction:
         (1) Fertilization is internal, and development is direct.
         (2) Some female spiders eat the male as sperm is transferred.
         (3) Scorpions retain fertilized eggs; once hatched, the young climb onto the mother's back until they are old enough to hunt.
   4. Insecta (Insects) (**Fig. 32.25**)
      a. Feeding:
         (1) The variety of insect mouthparts illustrates that they can feed on almost anything.
         (2) Larvae have wormlike bodies and are deposit feeders.
         (3) Adults are herbivores, predators, and parasites.
      b. Movement:
         (1) Insects use legs to walk, run, and swim.
         (2) They use wings to fly.
      c. Reproduction:
         (1) Sexes are separate, and fertilization is internal via copulation.
         (2) Most females lay eggs, although some are retained.
         (3) Some species can reproduce asexually through parthenogenesis.
         (4) Most species experience complete metamorphosis; some experience incomplete metamorphosis.

5. Crustaceans (Shrimp, Lobster, Crabs, Barnacles, Isopods, Copepods) (**Fig. 32.26**)
    a. Feeding:
        (1) Crustaceans use every type of feeding strategy known.
        (2) Barnacles and shrimp are suspension feeders that use feathery appendages to capture prey.
        (3) Crabs and lobsters are active hunters, herbivores, and scavengers.
        (4) Crabs and lobsters have mandibles that they use to bite and chew.
    b. Movement:
        (1) Many crustaceans have more than one type of limbs.
        (2) These include paddles for swimming, feathery structures for capturing food, jointed appendages for walking and running.
        (3) Barnacles are the only sessile crustaceans, but use their legs to draw food to them.
    c. Reproduction:
        (1) Sexes are separate, and fertilization is internal.
        (2) Eggs are usually retained by the female, and in most species the larval stage is called a nauplius.

Chapter Vocabulary

Protostomes
Drosophilia melanogaster
Caenorhabditis elegans

entomology
coelom
segmentation
acoelomate
pseudocoelom
tube-within-a-tube
hemocoel
foot
visceral mass
mantle
trilobites
jointed limb
proboscis
siphon
jet propulsion
parthogenesis
Lophotrochozoa
Rotifera
Annelida
Polychaeta
chaetae
parapodia
Clitella
Hirudinea
Mollusca/mollusks
Bivalves
veliger
Gastropods
radula
Cephalopoda/cephalopods
tentacles
beak
spermatophore
Polyplcophora/chitons

Ecdysozoa
molting
cuticle
detrivores
Nematoda/nematodes
Arthropoda/arthropods
head
trunk
compound eye
simple eyes
antennae
Myriapods
Chelicerata
chelicerae
Insecta/insects
head
thorax
abdomen
crustaceans
carapace
mandibles
nauplius